PRELIMINARY STATEMENT OF TORNADOES IN THE UNITED STATES DURING 1930

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In advance of the final study of the windstorms of 1930, which is expected to be finished during the summer of 1931, this preliminary statement, compiled from the material thus far assembled through the assistance of many, especially the several section directors, almost all of which was used in the monthly tables of "Severe local storms," is presented:

TORNADOES AND PROBABLE TORNADOES

	January	February	March	April	May	June	July	August	September	October	November	December	Year
Number	0	0	8	5	82	36	13	7	17	2	17	0	187
Deaths	----	----	4	0	114	8	0	0	5	3	32	----	166
Damage [1]	----	----	678	48	6,865	1,969	113	85	654	50	642	----	11,104

TORNADIC WINDS AND POSSIBLE TORNADOES [2]

	January	February	March	April	May	June	July	August	September	October	November	December	Year
Number	0	2	1	0	3	2	0	0	0	0	2	0	10
Deaths	----	0	0	----	1	0	----	----	----	----	0	----	1
Damage [1]	----	52	6	----	250	13	----	----	----	----	6	----	327

[1] In thousands of dollars.
[2] Several of these, in the final study, will probably be classed as not tornadoes.

In reviewing the 1930 material, from which this tabular statement was prepared, and the final studies of the years just preceding, it was noted that at the end of 1930 a period of 39 months had gone without any one tornado in the United States causing property losses to the amount of $2,500,000, or the loss of as many as 50 lives. However, on a few occasions a group of tornadoes visiting one State during one day had together caused more than 50 fatalities. In the aggregate, the tornadoes of these 39 months resulted in losses of 539 lives, according to the best information at hand, and about $36,000,000 of property.

By contrast, the tornado record of the slightly longer period of 45 months next preceding may be summarized; that is, from the beginning of January, 1924, to the end of September, 1927. Within this 45-month period there occurred six tornadoes causing losses of more than 50 lives each, the counts actually ranging from 67 to 689, while three of the six caused property losses exceeding $10,000,000 each. The total figures of losses from the tornadoes of these 45 months were 1,848 lives and almost $97,000,000 of property.

NOTES, ABSTRACTS, AND REVIEWS

Dr. George C. Simpson on Thunder and Lightning [1]—*Abstracted and condensed by A. J. Henry.*—Doctor Simpson, in his opening paragraph, points out that while it is nearly 200 years since Dalibard and Franklin showed conclusively that lightning is an electric discharge there is as yet no unanimity of opinion as to the mechanism by which the electricity is generated in the thunderstorm. He believes that at present there are but two theories that are seriously considered, viz, those of C. T. R. Wilson [2] based on electrical induction, and the one based on the breaking of raindrops.[3] The latter theory starts from the observation that when a drop of water breaks up in the air there is a separation of electricity, the water becoming positively charged and the air negatively charged.

In all thunderstorms there are violent ascending air currents which hold up large amounts of water in the form of rain drops. These rain drops are constantly breaking and reforming and the air which streams past them becomes negatively charged. In this way there is a large separation of electricity, the cloud as a whole becoming more and more charged with negative electricity, while the water held in suspension in the ascending currents becomes very highly positively charged.

For a long time it was considered that a cloud is more or less a good conductor of electricity. It is now known, according to Doctor Simpson, that this is not the case, and that when electricity is separated into two parts of a cloud it remains as a volume charge. If the process which separates the electricity continues the charge goes on accumulating until the electrical field becomes so intense that the electrical resistance of the air breaks down and a lightning discharge passes.

When air is subjected to an electrical stress little happens until a certain field strength is reached when "electrical breakdown" occurs.

[1] The thirty-second Robert Boyle lecture, delivered before the Oxford Junior Scientific Club, June 7, 1930.
[2] Journal Franklin Institute, 208, p. 1, 1929.
[3] G. C. Simpson; Proceedings Roy. Soc. A; 114, p. 376, 1927.

The breakdown is due to the splitting up of neutral air molecules into ions and electrons. Now, ions and electrons can move under an electrical field, and therefore when the air has broken down an electrical current can pass, the electricity being conveyed by the moving ions and electrons, especially the electrons which move several hundred times faster than the ions.

In a thunder cloud in which active separation of electricity is taking place the field increases until the electrical resistance of the air breaks down, generally at some point well within the cloud. At first the region of breakdown is very local but the rent, having once been started, rapidly extends in the form of a narrow channel; but the most important characteristic of such a rent is that it can only extend in one direction, that is, away from the seat of the positive electricity. As the channel extends, it tends to branch and each branch becomes a new rent. Thus when we see a lightning discharge we can tell from the branching which way it has extended and where the positive electricity is situated.

The rate at which a lightning channel grows is usually very great. It has not been possible to measure the rate of growth of a natural lightning channel; but from experiments made in the laboratory we know it can be as fast as one-tenth of the velocity of light. On the other hand, as I shall show later, the channel grows relatively slow. The light associated with a lightning flash is due to the recombination of electron and ions within the ionized channel. The first discharge which opens the channel leaves the air within the channel very highly ionized and so long as the channel remains ionized an electrical current can pass along it.

The current itself renews the ionization so that the channel continues to glow so long as a current passes. Recombination however, is relatively a slow process and the channel remains ionized for some appreciable time after the visible discharge has ceased.

The numerous different kinds of lightning are due to the different forms which the channel can take. Many attempts have been made to classify lightning discharges according to their forms; but as there are no hard and fast distinctions between the different forms the attempt has not been very successful. There are, however, several quite characteristic forms assumed by lightning which I propose to consider and explain them so far as the explanation is known.

Branched discharges between the earth and the clouds, by far the most common form of lightning discharge, is one with clearly defined branches. When the branches are directed away from the cloud it indicates that the cloud was positively charged. In other cases, but much more rarely, the branches are directed toward the cloud thus showing that the cloud was negatively charged. There is an important difference between two such discharges. When the positive charge is in the cloud each channel which reaches the ground only carries part of the electricity which left the cloud, for part of the charge is used up in the channel itself and a large portion passes through other branches, some of which never reach the ground at all. On the other hand when the cloud is negatively charged, the discharge starts on the ground and it is only later when the channel has grown upward that branching takes place. Thus all the electricity associated with a discharge from the ground to a negative cloud passes through a single channel when near the ground; therefore an object struck by such a discharge is more seriously damaged than an object struck by the attenuated end of a discharge from a positively charged cloud.

Doctor Simpson illustrates by half tones and discusses the different forms of lightning as enumerated below:

(1) Discharges between clouds; (2) stream discharges; (3) meandering flashes; (4) intermittent discharges; (5) pearl necklace lightning; (6) rocket lightning; (7) sheet lightning; and (8) ball lightning. In regard to the last named Doctor Simpson admits that he can not see even the beginning of an explanation and is unwilling to add another guess to the many that already have been made.

The above named forms are more or less familiar to readers of the REVIEW with the exception of rocket lightning. I therefore quote Doctor Simpson's description of this phenomenon:

> Rocket lightning: In the forms of lightning so far discussed the channel has been formed in such a short space of time that its formation could not be observed. The long duration of the flashes, especially with intermittent lightning, has been due to the discharge occupying the channel for a long period—sometimes as long as a few seconds—after it has been formed. There is, however, a type of lightning discharge which starts in a cloud and then progresses so slowly across the sky that the eye can follow its progress with ease, in the same way that the path of a rocket can be seen. I saw this phenomenon in Belgaum, India, in the year 1907. There was a thunderstorm in the distance, the cumulus cloud of which stood up sharp against the sky. From the lower part of the cloud a series of discharges took place, the discharges moving quite slowly in a horizontal direction to some considerable distance from the cloud. The effect was as though coiled up ribbons were being thrown out of the cloud which unrolled as they moved to the right. This slow-moving lightning has very appropriately received the name of rocket lightning.

E. M. Keyser on An Inland Empire Long-period Rainfall Riddle.—In an article entitled "An Inland Empire Long-Period Rainfall Riddle" in the July number of the MONTHLY WEATHER REVIEW, E. M. Keyser reviews two papers in evidence of a decided lack of synchronism between the long-period rainfall distribution in Spokane County, Wash., and the adjoining county of Bonner, Idaho.

O. W. Freeman, in one paper, on the evidence of the exposure of pine stumps in Silver and Granite Lakes, Wash., as the waters have receded in recent years, concludes that a past dry period of at least a century accounts for the presence of trees in what is now a lake, and that a wetter period, beginning two or three decades ago, caused the lake levels to rise, submerge the trees at their bases, and kill them.

Robert Marshall, in studying rates of growth in trees by stem analysis near Priest River, Idaho, finds evidence in support of a recent dry period coincident with the high lake level period in Granite and Silver Lakes and a previous wet period at the time when the trees whose stumps are exposed were growing.

It is noteworthy that Granite and Silver Lakes lie in the dry margin of a forested region. Timber in the vicinity is scarce, and just a few miles to the westward the country becomes definitely too dry for tree growth. It seems unlikely, therefore, that trees would thrive in the vicinity if it were considerably dryer than at present, unless locally abundant soil moisture as might be found in a seepage slope were present. In view of this, the trees whose stumps now appear in Silver and Granite Lakes are as good evidence in support of a past period of abundant moisture as they are in support of a dry period. Moreover, if their presence is the result of moister rather than dryer condition in the past, it is evidence of a rainfall cycle synchronous with that of Bonner County, Idaho, which would be expected from the proximity of the two localities. It is not unlikely, as Mr. Keyser suggested, that another explanation than increasing rainfall can be found for the submerging of the trees by the waters of Silver and Granite Lakes.—*Carleton P. Barnes.*

George C. Simpson on the Climate During the Pleistocene Period.[4]—Doctor Simpson, present director of the British Meteorological Office, continuing his studies of the climates of past geological ages, now presents a discussion of Pleistocene climate in an address given on June 16, 1930.

More than a score of methods of accounting for ice ages have appeared. The problem has been discussed by geologists, meteorologists, biologists, and others who may or may not come within those groups. No method has been universally accepted; therefore a fresh discussion, especially by one who has made a special study of the subject, is welcome.

Lack of space prevents us from presenting more than the summary of conclusions in the author's own words; these are not laid down with an air of finality, in fact the author admits that the record is not always clear and that inferences are at times difficult.—*A. J. H.*

SUMMARY

It is assumed that the glaciation of northern Europe during the great ice age was due to a shift of the pole associated with appreciable variations of solar radiation.

The shift of the pole brought Europe into sufficiently high latitudes to permit of the formation of an ice sheet; but the large variations of climate during the ice age, as shown by the interglacial epochs, were due to the oscillations of the solar energy.

If two complete cycles of solar radiation occurred during the Pleistocene period, it is possible to account for four advances of the ice in the Alps as demonstrated by Penck and Brückner, but the interglacial epochs were not all warm. The Günz-Mindel and the Riss-Würm interglacial epochs occurred at the maximum of the solar radiation and were, therefore, warm interglacial epochs; but the Mindel-Ries interglacial epoch occurred at a minimum of solar radiation and was, therefore, a cold interglacial epoch.

At a maximum of solar radiation—that is, during a warm interglacial epoch—the climate of northwest Europe was warm and very wet, with a relatively small annual variation of temperature. As the intensity of solar radiation decreased, the mean temperature fell and the annual variation of temperature increased. At the same time the amount of precipitation decreased. The fall of temperature occcurred sufficiently rapidly compared with the decrease in precipitation to cause the glaciers of the Alps to advance and for

[4] Reprint from Proc. Roy. Soc. Ddinburgh, Vol. L, Part III, No. 21.

an ice sheet to form over Scandinavia. As the solar radiation still further decreased, the lack of precipitation caused the glaciers of the Alps to retreat. At the minimum of solar radiation there was a cold interglacial epoch with low mean temperature, a large annual variation of temperature, and very low precipitation; in fact, a truly continental climate.

With these changes of climate went a corresponding change in the flora, the sequence being park land, forest, tundra, grass with sparse trees, and steppe. In this way it has been found possible to determine a sequence of climates and of fauna and flora for the whole Pleistocene period, which is supported by the geological and archæological evidence available. In particular it is possible to arrange the sequence of human culture, the geological strata of East Anglia, and the history of the ice in the Alps into the scheme of climate change.

The two maxima of solar radiation were accompanied by increased precipitation in all parts of the world, so accounting for the two pluvial periods which are known to have occurred during the Pleistocene period.

K. Knoch and E. Reichel[5] *on the Distribution and Annual March of Precipitation in the Alps.*—This work is the first attempt to summarize all the monographs and separated data published in four different countries, in three different languages. In the first chapter the authors discuss the origin of the data used.

The second chapter is a discussion of the distribution of the precipitation. The first problem to be solved was the drawing of the different maps. The greatest possible accuracy was obtained, but even in spite of the careful work the authors do not claim to present the actual, accurate amount of precipitation, but to give a basis for comparison regard to the precipitation and the height of the Alps.

There are five distinct regions (1) the dry region of the southern French Alps, relatively low, and in the Mediterranean climatic influence; (2) wet, west and north front Alps, first condensation of the westerly winds; (3) wet region of south and east Switzerland, warm south foehn and the uplift of the warm air masses by the influx of northern cold air; (4) the rainy region of the southeastern Alps, the nearness of the Adriatic Sea; (5) the dry regions of southwestern Switzerland and of the zone of the central Alps, rain shadow.

The dryness of the valleys is due to rain shadow affect. Interesting phenomenon is that of the rain beam. Every valley opens into a region of more precipitation, thus the isohyets of lesser precipitation form closed line on the valley bottoms. The amount of precipitation in the valleys depends entirely upon the direction of the valley in regard to the winds, and every change in direction results in a change in precipitation.

As to the theoretical maximum zone of precipitation lower than the maximum height of the mountains, the authors maintain that this does not exist in the Alps.

The third chapter deals with the yearly march of precipitation. The chief types are (1) summer rain, July maximum; (2) transition types; (3) equinox type, May and October maximum; (4) French type, October maximum; (5) highland types, irregular maximum.

In the fourth chapter the authors briefly discuss the variability of the means and the absolute variability of precipitation.

The last 30 pages are devoted to tables containing the mean annual precipitation values of all the stations available and their heights above sea level, monthly values and the monthly proportions of the yearly total, extreme monthly and yearly values, comparisions of the 10 and 20 years means with that of 40 (30) years.

There are four supplements, one precipitation map of the Alps (1:925,000), and 27 small maps showing the location of all the stations, the distribution of different types of rainfall, the maximums, the minimums, etc.

The greatest value of the work lies in the compiling of the material, in the careful examination and interpretation of the data, the preparing of the great number of graphs, diagrams, and maps; also, its style which is easily readable and lacking the general long sentences of the German scientific writings.—*Sigismond R. Diettrich, Clark University.*

[5] Verteilung und jährlicher Gang der Niederschläge in den Alpen. K. Knoch und E. Reichel. Veröffentlichungen des Preussischen Meteorologischen Instituts, M. 375, abhandlungen, Bd. IX, No. 6, Berlin, 1930. Price, 13 R. M., 84 pp., maps, tables.

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